examined by the author (Mr. Thos. Andrews), the crystalline jointings appearing to be similar in character.

A general analogy appears also to exist between the crystalline structure of pure platinum and that of pure gold, which is noticeable on comparing the illustrations in the present paper with those in the following papers, viz.: "On the Structure of Gold and Gold Alloys," by Professor J. O. Arnold,* and "On the Structure of Metals, its Origin and Changes," by M. Osmond and Sir Roberts-Austen.†

This identity of structure is further seen on referring to the illustrations in the paper on "The Microscopic Structure of Gold and Gold Alloys," by Mr. Thomas Andrews.‡

DESCRIPTION OF PLATE 6.

Micro-crystalline Structure of Platinum.

Fig. 1. Structure seen in section magnified 50 diameters. Oblique illumination.

Fig. 2. Primary and secondary crystals seen in section magnified 120 diameters. Vertical illumination.

Fig. 3. Primary and secondary crystals seen in section magnified 360 diameters. Vertical illumination.

Fig. 4. Primary and secondary crystals, magnified 360 diameters. Vertical illumination.

"The Distribution of Magnetism as Affected by Induced Currents in an Iron Cylinder when Rotated in a Magnetic Field." By Ernest Wilson, Professor of Electrical Engineering, King's College, London. Communicated by Sir W. H. Preece, F.R.S. Received January 3,—Read January 30, 1902.

One object of this research§ is to investigate the effect which induced currents have upon the distribution of magnetism in an iron cylinder when it is rotated about its longitudinal axis in a magnetic field whose direction is normally at right angles to the axis of rotation. Another object is to investigate the rate of dissipation of energy by these induced currents, and to compare the same with the result of theory. This second part of the work will be dealt with in a subsequent paper.

The variables dealt with are the total flux of magnetism between

* 'Engineering,' vol. 61, 1896, p. 176.

† 'Phil. Trans.,' A, 1896, p. 417, fig. 10, Plate 9, and fig. 16, Plate 10.

‡ 'Engineering,' September 30, October 28, December 9, 1898; see also "Micro-metallography of Iron," by Mr. Thomas Andrews, 'Roy. Soc. Proc.,' vol. 58, 1895.

§ I wish to acknowledge the grant of £80 for the purposes of this research, which was voted to me by the Council of the Royal Society out of the Government Grant.

the poles of the magnet used and the speed of rotation of the cylinder. The cylinder is of mild steel, and has diameter and length each 10 inches (25·4 cms.). It is shown in section in fig. 1. In order to find the average value of the intensity of induction over elements of the cross-section of the cylinder, holes $\frac{1}{4}$ inch (0·635 cm.) diameter are drilled as shown in a plane containing the axis of the cylinder. By threading insulated copper wires through these holes certain areas were surrounded and the ends of the coils brought out through a hole in the gunmetal shaft to a terminal board fixed thereto. The areas in fig. 1, numbered 1, 2, 3, I, II, III, have in each case been surrounded by exploring coils, each coil consisting of nineteen complete turns. Another coil is wound entirely round the cylinder in the same plane of section and numbered 4. A D'Arsonval galvanometer and resistance box were included in each circuit, and twin wires were used in each case to reach from the terminal board to the galvanometers.

The magnet consists of two slabs of soft iron each $40\frac{1}{2}$ inches (103 cms.) long, 19 inches (48·3 cms.) broad, and $8\frac{1}{2}$ inches (21·6 cms.) thick, joined together by a yoke at one end, giving a distance of 8 inches (20·3 cms.) between the opposing broad sides of the slabs. The cylinder rotates in gunmetal bearings bolted to the poles of the magnet, which are tapered so as to concentrate a powerful magnetic field upon the cylinder if necessary. The bore of the pole-pieces is $10\frac{1}{8}$ inches (25·7 cms.) diameter. The arc embraced by each pole-piece is 170°, and the length of the pole-piece next to the cylinder is 10 inches. The cylinder is turned by means of a worm and worm wheel. The worm wheel has 90 teeth, and the worm a single thread, so that one revolution of the worm shaft per second corresponds to a periodic time of 90 seconds for the cylinder. The wheel on the worm shaft is turned by hand, while by aid of a clock beating seconds and a scale fixed under the wheel the speed is controlled. For the highest speed the ratio of the gearing was increased four-fold. The operator at the wheel counted seconds aloud, thus enabling the epoch of the simultaneous observations at the galvanometers to be determined. The electromotive forces so obtained have been plotted in terms of the time on squared paper, and by integration the average value of the induction density with respect to any coil has been found. The area taken for each coil is that defined by the centre line of the drilled holes. The areas of coils Nos. 1, 2, 3 are each taken to be 25·8 sq. cms. The areas of coils I, II, III are taken to be 49·2, 51·6, 51·6 sq. cms. respectively, and the area of No. 4 coil is taken to be 645 sq. cms. Throughout the paper the curves of electromotive force are numbered to agree with the coils from which they have been obtained.

Before dealing with the results obtained, it may be stated that

these experiments have a wider application than to the cylinder experimented upon. Consider two similar homogeneous cylinders having the same magnetic properties and the same specific resistance, and let the ratio of their dimensions be n. As the magnetism penetrates from the outside into the iron by a diffusion process, and a kinematic coefficient of diffusion is of two dimensions in space and one inversely in time, it follows that if the cylinders be each rotated in a magnetic field of the same intensity, then to induce the same electromotive force at similar points the speed of rotation must vary inversely as n^2, and the induced currents will be similar in the two cylinders. In Table I is given the periodic time or frequency at which similar electric and magnetic events will happen in similar cylinders of different diameters.

I. *Radial Variation of Intensity of Magnetic Induction.*—Five different periodic times have been dealt with, namely, 360, 180, 90, 45, and 22·5 seconds. The collected results for 360, 90, and 45 seconds are given in figs. 2, 4, 6 respectively, and have been taken from Table II which contains the complete data. The curves show approximately how the maximum intensity of induction varies at different depths of the cylinder, and have been obtained by first plotting the maximum average induction per sq. cm. for each coil 1, 2, 3 at its mean radius. We notice at once how marked is the effect of variation of frequency upon the distribution of induction. Moreover, for the smaller periodic times we notice how much more marked are the effects for intermediate values of the external magnetising force.

The maximum intensity of induction at the surface of the cylinder has been taken from curves, and in each case the corresponding value at the centre has been expressed as a percentage of it. Fig. 7 gives the results so obtained plotted in terms of the maximum intensity of induction at the surface. The curves are numbered 360, 180, 90, 45, 22·5 to correspond with the periodic time in each case. We see that as the frequency is increased the centre is more shielded; moreover with increase of frequency the range over which the interior of the cylinder is shielded is increased. At 45 seconds periodic time the surface value of the intensity of magnetic induction at which the effects of induced currents begin to rapidly diminish is about 16,000. At 90 seconds it is about 11,000, but the rate is slower. At 180 seconds the change starts at about 7000 and is more gradual. At 360 seconds the disturbing effects due to induced currents are probably small. The distribution of intensity of induction when the cylinder is not rotating is not known, and probably varies with the intensity of magnetic force. The curves in fig. 2 may perhaps be trusted to give some indication of the distribution if the cylinder was not rotating. The dotted curve in fig. 2, giving B 15,400 at the centre of the cylinder, probably gives this value too low, owing to some unknown error. The curve is

given, as the author does not wish the paper to show a greater accuracy than the experiments are entitled to.

The way in which the magnetism is crowded to the surface at the higher speeds can be well seen in Table II. With a periodic time of 22·5 seconds the value of maximum average induction density near the surface is 10,770, for a maximum average over the whole cylinder of 6850. With a periodic time of 360 seconds a maximum average over the whole cylinder of 6970 is obtained with a maximum average near the surface of 7170. The values of maximum induction density at the surface are 17,000 and 7000 in the above examples respectively.

II. *Alternating Magnetic Force.*—It is interesting to compare the results just given with those obtained from a cylinder 12 inches (30·5 cms.) diameter when under the influence of an alternating magnetic force directed along the longitudinal axis. This cylinder is of mild steel and has probably nearly the same magnetic and electric properties as the cylinder in fig. 1 at the same temperature. Holes are drilled in the 12-inch cylinder in a plane at right angles to the longitudinal axis in much the same manner as in the rotating cylinder. Taking the areas as bounded by the centre lines of the drilled holes, the data in Table III have been obtained, and the curves in figs. 3, 5 have been plotted therefrom.* In fig. 3 the periodic time was 10·3 minutes, corresponding to a frequency of 150 periods per second with a cylinder 0·1 cm. diameter. In fig. 5, the periodic time was 2·6 minutes, corresponding to a frequency of 600 periods per second with a cylinder 0·1 cm. diameter. We see by Table I that figs. 2 and 4 can refer to a cylinder of diameter and length 0·1 cm., when rotating at frequencies 179 and 717 periods per second. Comparing figs. 4 and 5, we see that there is a similarity, but with the alternating magnetic force the shielding effect is more severe than with the rotating field.

This is perhaps better seen by referring to fig. 7, where the points marked × are taken from fig. 5, and should be compared with curve 90. It will be seen that with the alternating magnetic force, the severity is about as great as at 1434 periods per second (curve 45) with the rotating force. Similarly, by comparing figs. 2 and 3, and the results obtained therefrom in fig. 7, namely, curve 360 and the points marked ⊗, we see that for the same diameter of cylinder (0·1 cm.) the effects are much more marked with the alternating force. The points lie fairly well on the curve numbered 180. The same remarks refer to the maximum average over the whole section.

It should be noted that the area of No. 1 coil in these experiments, which is the same as the innermost coil in the case of the alternating

* See Wilson, 'Roy. Soc. Proc.,' vol. 68, p. 218. The figures in italics in the table at the end of this paper have been re-calculated, owing to an error in estimating the areas.

magnetic force, bears a somewhat larger ratio to that of the whole section (fig. 1) than in the case of the alternating force.

The conclusion is, however, that with an alternating magnetic force having a direction parallel to the longitudinal axis of a cylinder of given diameter, the effects of induced currents examined in this paper are more severe than in the same cylinder, of length equal to diameter, when rotated about its longitudinal axis in a magnetic force whose direction is at right angles to the axis of rotation for corresponding values of the frequency and the surface-induction density.

It should be remembered that in the case of alternating magnetic force, the electromotive force of a coil embedded in the iron is due to a true reversal of magnetism in the iron, and all the magnetic forces can be referred to a given cross-section of the iron cylinder. With a rotating field, the magnetic forces are referred to position in space.

Table III gives the values of the intensity of magnetic induction at different points of the 12-inch cylinder under alternating magnetic force. It also gives the relative phase-displacement of the electromotive-force curves obtained from the exploring coils.

III. *Phase-displacement.*—The preceding remarks have dealt with the maximum intensity of induction experienced each half-period at different points along a radius of the cylinder. In Table II are given the phase-displacement of the electromotive-force curves for coils 1, 2, and 4 with regard to the electromotive force of No. 3 coil. Referring to fig. 6, we saw how very sensitive the induction density at the centre of the cylinder is to changes at the surface in the region of 16,000, and this is when the maximum phase-displacements are experienced. For a very small change in the intensity of magnetic induction at the surface, when of the order 16,000, the interior of the cylinder experiences variations ranging from 738 to 7830. The phase-displacements change very abruptly, for when the induction density at the surface is 18,500, the phase between the electromotive-forces of coils 1 and 3 has dropped to 15° from 122° at 16,400. For very high induction density the curves are practically in phase. With the smallest value of induction density at the surface (180), the phase-difference between the electromotive forces of Nos. 1 and 3 coils is 44°.

The phase-displacements in Table II have been judged from the points at which the respective electromotive-force curves cross the axis of time. This can be done with a good deal of certainty, but with the alternating magnetic force (Table III) this is not always the case. If reference be made to the electromotive-force curves,* it will be seen how different in character they may be when compared with those obtained with the rotating cylinder. In Table III the phases have been judged from the centre of gravity of the area inclosed by the electromotive-force curve and the axis of time per half-period.

* See Wilson, 'Roy. Soc. Proc.,' vol. 68, p. 218.

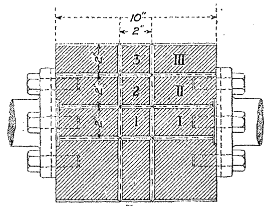


Fig. 1

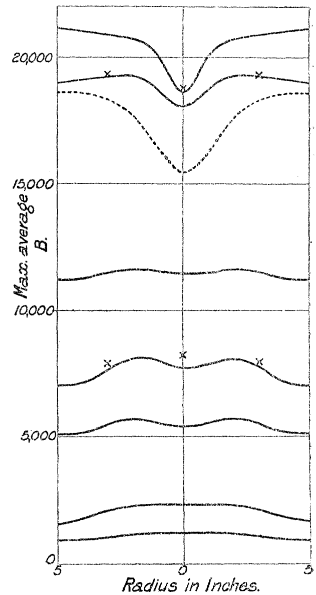


Fig. 2.

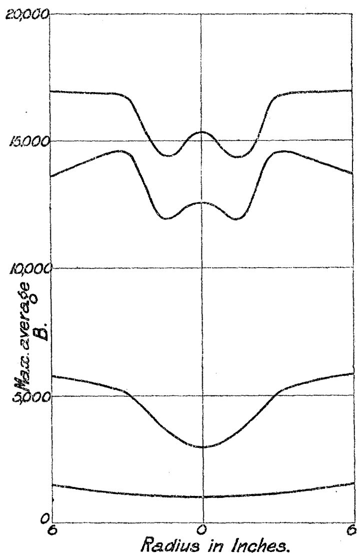


Fig. 3.

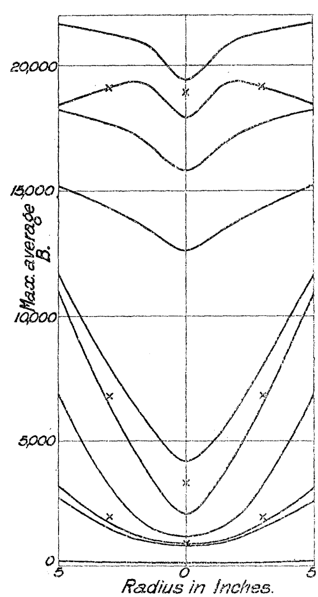


Fig. 4.

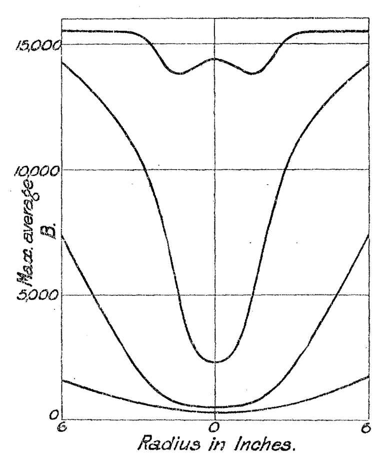


Fig. 5

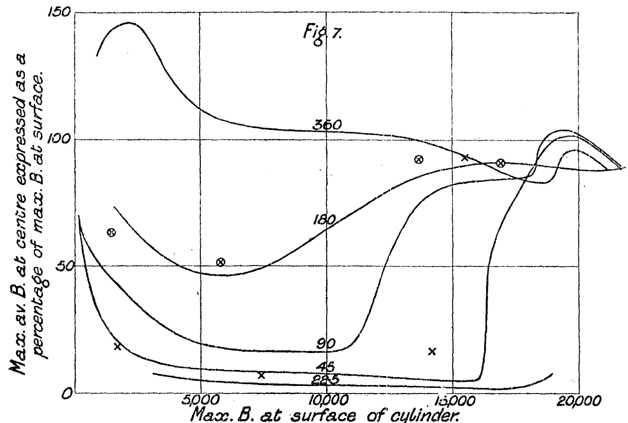


Fig. 7.
Max. av. B. at centre expressed as a percentage of max. B. at surface.
Max. B. at surface of cylinder.
360
180
90
45
22.5
150
100
50
0
5,000
10,000
15,000
20,000

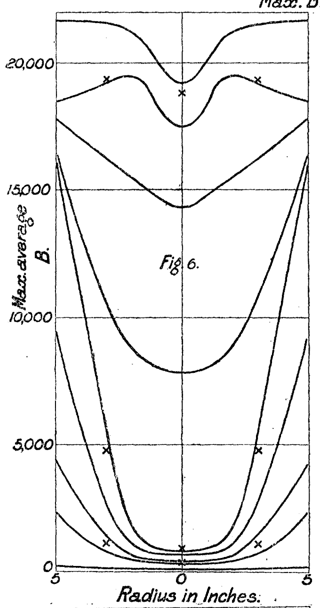


Fig. 6.
Max. average B.
Radius in Inches.
20,000
15,000
10,000
5,000
0
5
0
5

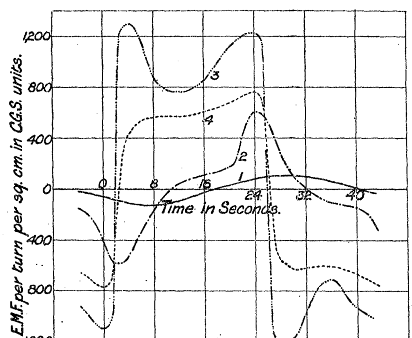
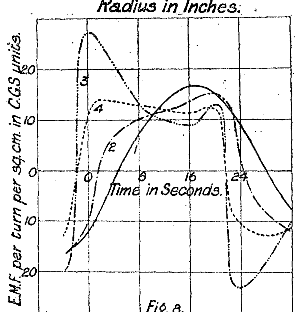

E.M.F. per turn per sq. cm. in C.G.S. units.
Time in Seconds.
1200
800
400
0
400
800
1200
0
8
16
24
32
40
1
2
3
4

Fig. 9.


E.M.F. per turn per sq. cm. in C.G.S units.
Time in Seconds.
20
10
0
10
20
0
8
16
24
1
2
3
4
Fig. 8.

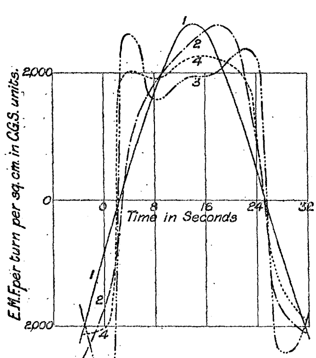

E.M.F. per turn per sq. cm. in C.G.S. units.
Time in Seconds
2,000
0
2,000
0
8
16
24
32
1
2
3
4

Fig. 10.

With alternating magnetic force the phase-displacement is more severe than in the corresponding condition with a rotating magnetic field. At frequency 600 with alternating magnetic force the maximum phase-displacement with a cylinder 0·1 cm. diameter is of the order 160°. With rotating magnetic force of frequency 1434, for a cylinder of diameter and length each 0·1 cm., the maximum phase-displacement is 122° and at 717 periods per second it is only 104°.

Table II shows that maximum phase-displacement occurs at lower surface induction density the lower the frequency. This is also the case in Table III with alternating magnetic force.

It is unnecessary to publish all the curves of electromotive force obtained. Figs. 8, 9, and 10 refer to a periodic time of 45 seconds, and the corresponding values of induction density can be seen in Table II. Fig. 8 gives the initial stages with small external magnetic force in which the phase-displacements are relatively small, and the No. 1 and 2 electromotive forces are important. In fig. 9, the electromotive forces of Nos. 1 and 2 coils are relatively smaller, and the phase-displacements are large. In fig. 10, with high external magnetising force, the electromotive forces are in phase and of equal relative importance.

It is interesting to note the relation between the average permeability of the iron cylinder, and the rate at which the magnetism is propagated to the centre. When the permeability is small the effects penetrate rapidly. With large permeability in the iron the centre is reached with greater difficulty, hence the diminished value of the induction density at the centre and the increased phase-displacement. With the high limits of induction density the average permeability is small and the effects can penetrate more rapidly.

With intermediate magnetic force at 22·5 seconds periodic time, the electromotive force of No. 1 coil is diametrically opposed to that of No. 3 coil. That is to say, the intensity of induction at the centre of the cylinder is in the same direction as near the surface but of reversed sign.

IV. *Longitudinal Variation of Intensity of Magnetic Induction.*—The preceding remarks refer to the variation of intensity of induction over a section of the cylinder at its centre 2 inches (5·08 cms.) thick. We have seen how the magnetism is propagated over this section radially towards the centre. It is necessary to deal with the variation of induction density as one proceeds from either end of the cylinder to its centre.

The electromotive forces of each of the coils I, II, III (fig. 1) were observed simultaneously as in the case of coils 1, 2, 3, and by integration the maximum average intensity of magnetic induction over each area has been found. An examination of these curves shows that the effects of induced currents penetrate from each end of the cylinder

along area I in much the same way as was observed radially—that is to say, the intensity of induction diminishes in value and suffers retardation in phase. Table IV gives the values of the induction density and the phase-displacements for periodic times of 360, 90, and 45 seconds. In order to compare the diminution of induction density as one proceeds along the axis of the cylinder towards the centre, the maximum average values of induction density over Sections 1 and I have been plotted in figs. 2, 4, 6. The points are marked $\times$ and agree fairly well with the corresponding curves. The phase-displacements are shown in Table IV, and are a maximum for the intermediate force. Comparing the maximum average values of the intensity of induction over Sections 2 and II, we see that the corresponding differences are not so great and the phase-displacements are less. The maximum average values of induction density over Sections 3 and III are more nearly equal and the phase-displacements are small. Lastly, comparing the maximum average intensities of induction over areas I, II, III, we see that the diminution is not so great as over the areas 1, 2, 3, and the corresponding phase-displacements are less.

V. We have seen that with a cylinder of 10 inches axial length, the induced currents do not seriously disturb the approximately uniform distribution of induction density over its section, when rotated in a magnetic field with periodic time 360 seconds. This periodic time corresponds to a frequency of 179 periods per second in a cylinder of axial length 0·1 cm. In ordinary dynamo-electric machines the frequencies usually met with are very much smaller than 179, and plates 0·1 cm. thick are used. The inference is, that in cases in which as good an approximation to a pure rotating field as has been obtained in these experiments is met with, no serious deviation from uniform distribution exists, provided the plates are insulated from one another.

VI. Induction motors for a certain class of work are now supplied with solid iron armatures. Suppose such a motor with an armature 10 inches diameter and 10 inches long, and with one period per revolution, is placed on a supply system having a frequency of 30 periods per second. Fig. 6 refers to a periodic time of 45 seconds, or a frequency of 0·022 period per second. To obtain the effects observed at this frequency the armature would have to rotate at frequency 29·978—that is, the effective frequency or "slip," as between the rotating field, which would have to be as uniform as in these experiments, and the armature is 0·073 per cent. of the frequency of supply. To obtain the effects observed at 22·5 second periodic time, the effective frequency would be 0·146 per cent. of the frequency of supply. A slip of 5 per cent. could easily be obtained in practice, and this would correspond to an effective frequency sixty-eight times

as great as in fig. 6. Apart from phase-displacements we see that the interior portions of the cylinder would be quite useless with regard to induced magnetism, unless very large or very small external magnetising forces were employed.

VII. Experiments were made upon a steel wire 0·01 inch (0·00254 cms.) diameter, the object being to discover if a true time lag in magnetism exists.* Frequencies of 5, 72, and 125 periods per second were tried, and the results obtained were compared with the curve of magnetic hysteresis obtained by the Ballistic-galvanometer method. The curves so obtained would indicate a somewhat higher dissipation of energy with the high frequencies. Now the effects shown in fig. 3 would also be observed in a wire 0·01 inch diameter if the frequency were 600. The inference is that at 125 periods per second there would still be disturbances due to induced currents. The author inclines to the opinion that the effects associated with time lag in magnetism may be due to induced currents in the wire.

VIII. Lord Kelvin has computed that the earth's magnetism is travelling in the direction of the sun round the earth with a periodic time relatively to the earth of 960 years. The magnetic declination at London had an amplitude of 24° 34′ 30″ W. in 1820. Diurnal variation is observed to the extent of some minutes of arc. The reaction of the induced currents in the cylinder produces a displacement of polarity. In a cylinder similar in all respects to the one experimented upon, but having a diameter equal to that of the earth, a periodic time of 960 years would produce similar magnetic and electric events as would be observed in the 10-inch cylinder if the latter could be rotated with a periodic time 12×10^{-6} second. This is nearly 2,000,000 times as fast as the fastest speed in these experiments. Diurnal changes in spite of small magnetic force would produce effects confined to the surface of such a cylinder, and would not appreciably disturb an effect due to a periodic time of 960 years. Table II shows that when the intensity of magnetic induction at the surface of the 10-inch cylinder has the value 169, phase differences of the order 44° (360° = 1 period) are experienced with a periodic time of 45 seconds. The magnetic force H per centimetre linear in C.G.S. units would be about 0·5 in this iron, giving an average permeability of about 280. This is a force of the same order as the earth's total intensity.

IX. If we were to work upon smaller and smaller masses of iron until we reached the limit at which all the properties of the original mass were still preserved, we should require enormous speeds of rotation to produce the disturbances examined in this paper. Suppose the diameter of such a mass were of the order 0·000,0001 cm., then to produce similar effects to those which we have observed at 90 seconds

* See Hopkinson, Wilson, and Lydall, 'Roy. Soc. Proc.,' vol. 53, p 352.

periodic time, such a body would have to rotate at 7×10^{14} revolutions per second.

I wish to thank Messrs. Siemens Bros. and Co. for the loan of the field magnet, which was altered for the purpose of these experiments.

I have pleasure in acknowledging the help I have received from Mr. F. S. Robertson and Messrs. H. A. Skelton, R. M. Wartze, and M. S. Duffitt. Mr. Skelton has spent a great deal of time in the working out of the results. Mr. T. Jones has also rendered valuable assistance.

Table I.

Diameter and length each 25·4 cm.	Diameter and length each $12 \cdot 7 \times 10^8$ cm.	Diameter and length each 0·1 cm.
Periodic time.	Periodic time.	Frequency.
360 seconds	—	179 periods per second.
90 "	7×10^9 years............ $2 \cdot 2 \times 10^{17}$ seconds........	717 " "
45 "	—	1434 " "
12×10^{-6} seconds....	960 years. $3 \cdot 03 \times 10^{10}$ seconds.	
$1 \cdot 3 \times 10^{-8}$ "	1 year. $3 \cdot 1 \times 10^7$ seconds.	
$3 \cdot 5 \times 10^{-11}$ "	1 day. $8 \cdot 6 \times 10^4$ seconds.	

Table II.—Rotating Magnetic Force.

Periodic time in seconds.	Frequency for a cylinder of diameter and length 0·1 cm.	Maximum average induction B per sq. cm.				Phase-displacement of E.M.F. relative to E.M.F. of No. 3 coil. 360° = 1 period.			Figure.
		Centre. Coil 1.	Radius 2 inches. Coil 2.	Radius 4 inches. Coil 3.	Over whole section. Coil 4.	Coil 1.	Coil 2.	Coil 4.	
22·5	2868	234	282	1,807	1,177	102	57·6	3·2	
,,	,,	373	1,109	10,770	6,850	176	96	12·8	
,,	,,	1,504	6,530	14,840	10,500	186	115	22·4	
45	1434	124	128	169	137	44	19	11	8
,,	,,	371	466	1,356	959	69	36	5·6	
,,	,,	426	629	2,710	2,030	80	40	5·8	
,,	,,	714	1,067	5,645	3,720	86	42	5	
,,	,,	738	1,760	10,900	6,840	119	66	3·8	9 } 6
,,	,,	7,830	8,780	13,300	11,800	122	58	3·8	
,,	,,	14,260	15,460	17,000	16,570	15	13	4·8	
,,	,,	17,500	19,510	18,800	20,400	2	2	5·5	
,,	,,	19,210	21,230	21,650	22,020	−1·6	−1·6	−2·2	10
90	717	116	155	163	147	34	18·4	2·4	
,,	,,	894	1,115	2,085	1,705	43	21	1	
,,	,,	916	1,204	2,380	1,883	47	25	3·7	
,,	,,	1,174	1,901	4,890	3,540	58	26	3·2	
,,	,,	2,090	4,540	8,586	7,360	88	40	14	
,,	,,	4,164	6,342	9,757	8,456	104	46·5	14	} 4
,,	,,	12,570	13,810	14,800	14,600	14	10	1·6	
,,	,,	15,750	17,250	18,000	17,200	2·1	4·8	0	
,,	,,	18,000	19,400	18,780	20,000	3·5	4	8	
,,	,,	19,400	21,050	21,480	21,700	0	2·4	0	

Table II—*continued.*

Periodic time in seconds.	Frequency for a cylinder of diameter and length 0·1 cm.	Maximum average induction **B** per sq. cm.				Phase-displacement of E.M.F. relative to E.M.F. of No. 3 coil. 360° = 1 period.			Figure.
		Centre. Coil 1.	Radius 2 inches. Coil 2.	Radius 4 inches. Coil 3.	Over whole section. Coil 4.	Coil 1.	Coil 2.	Coil 4.	
180	358	1,163	1,389	1,525	1,350	21	9·6	1·6	
,,	,,	2,348	3,018	4,220	3,680	25·5	12·8	6·4	
,,	,,	6,160	6,830	8,710	7,790	51·8	22·8	2·6	
,,	,,	10,000	11,000	12,040	11,200	27·6	13·2	5·3	
,,	,,	15,050	17,000	16,690	16,480	3·2	4	0	
,,	,,	18,180	20,090	20,500	20,470	0·5	1·3	0	
,,	,,	19,500	21,130	21,600	21,570	0	0	0	
360	179	1,199	1,193	947	951	21	12	8	2
,,	,,	2,309	2,274	1,810	1,970	13·6	12·8	2·3	
,,	,,	5,290	5,711	5,159	5,233	17·5	10·4	4	
,,	,,	7,670	8,180	7,170	6,970	20	11·2	4·5	
,,	,,	11,470	11,600	11,290	11,630	8·8	6·0	3·2	
,,	,,	15,400	17,200	18,600	18,400	2	1·2	2·8	
,,	,,	18.000	19,300	19,110	20,000	4·8	3·6	1·7	
,,	,,	18,600	20,740	21,010	21,470	0·8	1·6	1·6	

Table III.—Alternating Magnetic Force.

Periodic time in seconds for a cylinder 12 inches diameter.	Frequency for a cylinder 0·1 cm. diameter.	Max. H due to magnetising current in copper coils on magnet.	Maximum average induction B per sq. cm.					Phase-displacement of E.M.F. relative to E.M.F. at radius 5 inches. 360° = 1 period.			Figure.
			Centre.	Radius 1·5 inches.	Radius 3 inches.	Radius 5 inches.	Over whole section.	Centre.	Radius 1·5 inches.	Radius 3 inches.	
618	150	1·10	965	—	—	1,340	1,200	79	—	—	3
,,	,,	2·82	2,950	3,630	5,140	5,670	5,085	106	86	45	
,,	,,	9·60	12,600	11,900	14,600	14,000	14,140	69	55	31	
,,	,,	16·70	15,300	14,400	16,800	16,900	17,870	41	32	19	
312	300	1·10	661	—	—	1,565	1,260	48	—	—	
,,	,,	9·45	11,500	11,150	13,700	13,860	13,020	115	88	48	
156	600	1·10	362	—	—	1,280	884	67	—	—	5
,,	,,	2·88	523	680	1,930	5,540	3,617	118	91	55	
,,	,,	9·51	2,310	5,200	10,670	13,300	10,420	158	122	61	
,,	,,	16·9	14,400	13,800	15,400	15,500	15,500	104	80	41	

Table IV.

Periodic time in seconds.	Maximum average induction B per sq. cm.						Phase-displacements. 360° = 1 period.						
	Centre. Coil 1.	Centre. Coil I.	Radius 2 inches. Coil 2.	Radius 2 inches. Coil II.	Radius 4 inches. Coil 3.	Radius 4 inches. Coil III.	Coils 3 and 1.	Coils 3 and 2.	Coils I and 1	Coils II and 2.	Coils III and 3.	Coils III and I.	Coils III and II.
45	470	1,090	592	840	1,692	1,930	70	35	58	34	7	16	8
,,	864	4,750	2,320	5,430	10,300	11,040	118	64	93	46	7	32	25
,,	18,800	19,300	19,500	18,900	18,800	20,000	2	2	3	2	4	3	4
90	933	1,960	1,210	1,550	2,140	2,340	47	22	36	15	0	12	7
,,	3,386	6,850	5,300	6,990	9,760	10,000	101	45	70	33	−3	26	9
,,	18,800	19,200	19,300	19,500	18,650	19,500	1·5	3	0	9	1·5	3	−4
360	8,260	7,900	7,980	6,780	6,580	6,350	18	12	16	11	2·4	4·4	3
,,	18,500	19,350	20,000	19,650	19,110	19,320	0	0	0	0	0	0	0

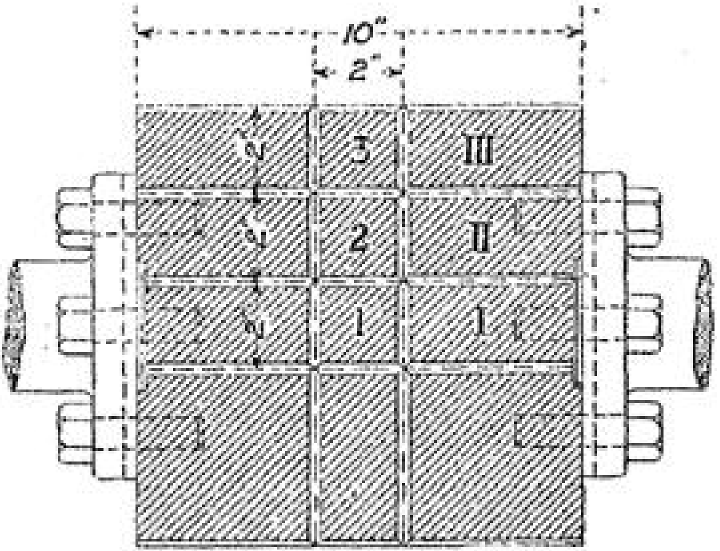


Fig. 1